Original Research Article

Variability and functionalities of salts used in Traditional African food preparations

ABSTRACT:

Aims: determine the variability and usages of Traditional Alkaline Salts used in Africa, specifically in Cameroon.

Place and duration of the study: This study was done in different agro-ecological areas of Cameroon between January and August 2015.

Methodology: individual interviews of women (204) found in markets of different Agro-ecological areas of Cameroon (Sudano-sahelian, high Guinea savannah, Western highlands and Humid forest) by using a semi-structured questionnaire.

Results: Traditional Alkaline Salts used in Cameroon are rocks (Lakes' deposits) and plant-based salts (plant-based ashes, their solutions, their filtrates and evaporites of these filtrates). They are mainly used in food preparations, but also as drugs (rocks only). They are used in food preparation as technological auxiliary (preservatives, emulsifiers, taste improvers, color improvers/maintainers, texture improvers/modifiers) and for biological functionalities (avoidance of stomach distending and stomach cleaning of breastfeeding women).

Conclusion: Diversity of TAS, their functionalities, frequency and level of use, raise up research issues on their chemical composition, the mechanism involved in their properties, their stability and their toxicology risk.

***Keywords**: Traditional Alkaline Salts, Lakes' deposits, plant-based salts, Usages, Functionalities*

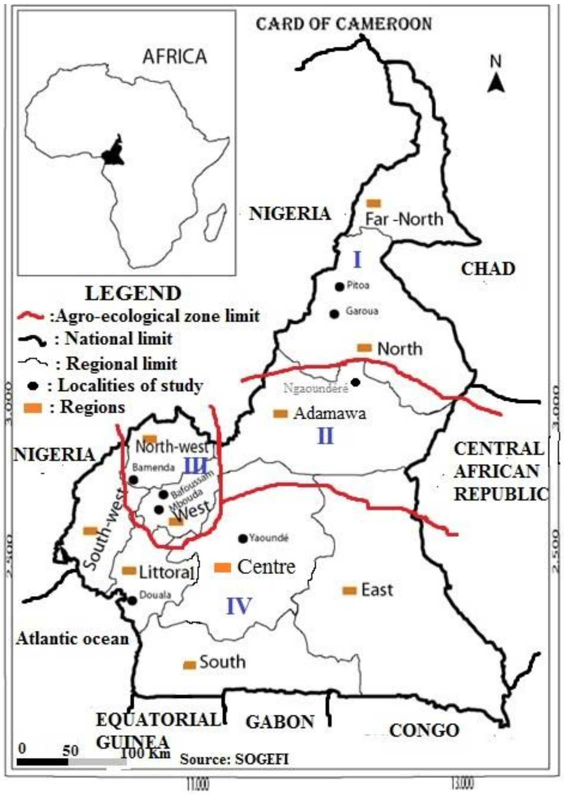
1. INTRODUCTION

Common edible salt, a natural evaporite which can be obtained from sea, underground ore or natural brine, and containing at least 97% of sodium chloride (NaCl), is the main salt used in food preparations, with the only objective to improve the taste of foods [1–4]. Out of that, other specific salts which have been reported to be used in food preparations are Lakes' deposits [5–11], plant-based ashes [12–17], their filtrates [12,18–22] and evaporites of these filtrates [17,23–26]. Their chemical composition shows that they are mixture of salts and thus, made of cations and anions, major cation being generally sodium or potassium whereas major anions are generally carbonates, bicarbonates, sulfates and chlorides [9,10,13,16,19,21,24,26–29]. Their usages have mostly been reported in African countries (Nigeria, Niger, Chad, Cameroon, Ghana, Kenya, Burkina Faso, Uganda, Tanzania, Sudan, Central and East African countries) [5,9,10,12,14,18,21,23,30,31], Asia (Indonesia, India and Sri Lanka), Oceania (Papua New Guinea) and South America (Bolivia, Paraguay, Colombia and Peru) countries [13,16,19,24,26,32–34]. Since the usages of these specific salts used in food preparations date-back long (up to 4000 years before Christ) [21,24,35], and that they seem to initially have been developed in areas where common sodium chloride salt was not available [21], they can be named Traditional Salts. In Africa, they have been reported to be used to reduce the cooking time of legumes, vegetables and cereals [11,12,22,31,36,37], to improve the green color of vegetables as well as to increase the viscosity of sticky ones [38,39], as emulsifier [20,30,40,41], and as flavor enhancers [27,36]. These functionalities have been attributed to the alkalinity of their aqueous solutions [11,12,15,31]. Since the solutions of Traditional Salts are alkaline, they can also be named Traditional Alkaline Salts (TAS). Up to now, studies involving TAS have been focused on their chemical composition [8–10,13,19,21,24,26,28,30], their effect on the nutritional quality of foodstuffs [15,42–45], their effect on the taste of food preparations [12,15] and their toxicological effect [7,14,46,47]. With respect to their functionality, only their ability to reduce the cooking time has been studied [6,12,22,23]. Very few studies have attempted to determine the functionalities and salt concentrations associated with usages of TAS at household scale in food preparations, as well as diversity of TAS used to achieve these objectives in a given area, and when done, only the reduction of cooking time was targeted on some selected food matrices (maize [*Zea mays*], sorghum [*Sorghum bicolor* L. Moench] and common beans [*Phaseolus vulgaris*]) [12,31]. It is certain that, the variability of functionality of TAS vis-à-vis food preparations is known to be beyond those studied. In fact, research studies on functional, nutritional and toxicological effects of TAS should be supported by the know-how and perception of users at household level. It is in the willing to fill this gap that the present study aims at determining, through a survey, the variability and characteristics of TAS found in Cameroon as well as their functionalities and concentrations used to achieve these functionalities at household scale.

2. MATERIAL AND METHODS

2.1. Selection of survey areas

The survey has been carried out in eight localities (Pitoa, Garoua, Ngaoundéré, Yaoundé, Douala, Bafoussam, Mbouda and Bamenda) located in all the agro-ecological zones of Cameroon [48] (figure 1). The choice of these survey areas was based both on the cosmopolite character of big towns (Douala and Yaoundé) where people from different ethnic origins are found, and on local usage habits of TAS in some towns (Pitoa, Garoua, Ngaoundéré, Bafoussam, Mbouda and Bamenda). In each locality, survey was carried out in markets, each market being selected on the basis of the witness of at least five stalls where TAS were sold.



Symbol	Agro-ecological zone	Rainfall (mm/year)
I	Sudano-sahelian	400-1200
II	High Guinea savannah	1500
III	Western highlands	1500-2000
IV	Humid forest	1500-4000

Source: Ngom *et al.*, 2014

Figure 1: Cameroon administrative and agro-ecological map

2.2. Characteristics of the target population

Only women have been selected for the survey, because they are generally in charge of the preparation of meals at household scale. In each market, at least fifteen women (traders and household users of TAS) were questioned. Questions were asked to only one woman at the time and altogether, 204 women from 13 markets of survey areas have answered the totality of the questionnaire. 20 (9.8%) women were of less than 30 years old, 96 (47.1%) women were between 31 and 60 years old, and 13 (6.4%) women were above 60 years old. 74 women (36.3%) did not indicated their age, but generally, they were estimated as belonging to the two first groups. 56.3% of women originated from Western highlands zone, 4.9% from high Guinea savannah zone, 28.5% from Sudano-sahelian zone, and 6.4% from Humid Forest zone.

2.3. Structure and application of the interview

The survey was carried out using a semi-structured guide addressing four groups of questions: *i)* age and region of origin of the interviewed woman; *ii)* types of TAS known and used, local names, origin when rocks were concerned, manufacturing process(es), plants' parts used as well as determinants of their appearance and efficiency when plant-based TAS were concerned; *iii)* main usages of TAS in food preparations, concerned food matrices, relative concentrations of TAS used for each food matrix, sought functionalities and quality attributes; and *iv)* other perceived functionalities such as digestive and health effects of TAS. These questions were asked to traders and users of TAS. All the stakeholders were enlightened about the objectives of the survey as well as questions for which answers were sought. It is only when the stakeholder was consenting to participate and was available to answer all the questions that the survey was carried out. In the specific case of TAS users randomly selected on the market, the interview started after ensuring that the interviewed woman knows and/or uses TAS, through a presentation of TAS samples bought on the current market. Regardless of the involved stakeholder (users and/or traders), no hint was given during the overall interview.

2.4. Data analysis

The collected data were recorded and analyzed through frequency count of observed evens, using Sphinx Plus[2] V.5.1.0.7 software package.

3. RESULTS AND DISCUSSION

3.1. Types of TAS used in Cameroon

Two types of TAS are found and used in Cameroon: rocks, imported from neighboring countries, particularly Chad, and plant-based salts locally manufactured by household users. Plant-based salts are of three types: *i)* plant-based ashes, obtained by combustion of plants' parts; *ii)* water extracts of plant-based ashes (filtrates or supernatant of an agitated mixture of water and ashes) which can be grouped in the term "Plant-based ash filtrates", and *iii)* evaporites of plant-based ash filtrates.

3.1.1. Types of rocks used as TAS

8 types of rocks have been identified on markets, among which 2 are specifically used in food preparations, 5 are exclusively used as drugs and one is both used as drug and as food ingredient (Table 1). Out of their usages, these rocks are commonly described by their color or their local names, depending on the area of usage. Two main representative common names, *Kanwa* and *Kilbu*, appear as more representative of the designation of rock salts (figure 2) used in food preparations. *Kanwa* designation is common to all the agro-ecological zones, particularly in Humid Forests and Western Highlands, while *Kilbu* is predominant in Sudano-sahelian zone, and compete tied with *Kanwa* in High Guinea Savannah. Other terms such as *Potash*, *Sel gemme* or *Limestone* appear in some reduced area of Western Highlands and Humid Forest and could be attributed either to the influence of neighboring countries like Nigeria [49], or to assimilation, in terms of properties (solubility and alkalinity in particular), with industrial mineral (*Potash*) or other naturally-occurring rocks (*Sel Gemme* and *Limestone*) known by populations, particularly in cities and among educated people. In general, the common denomination of *Kanwa* has been reported in Sahelian countries [8,10,30,49,50].
Out of the differentiation of rocks based on their color or names, their properties and efficiency constitute other differentiation indexes. For instance, though white and black *Kanwa* are exclusively dedicated to food preparations, the white color seems to be the most preferred TAS. It is found mainly in Sudano-Sahelian area, while in the southern areas towards forest, the black color emerges and have tendency to dominate. According to women, the white color of TAS is purer, more friable, more soluble and more convenient in food preparations, while the black one is denser; not friable, contains sand and is less soluble.
Women originating from Sudano-sahelian agro-ecological zone seem to be those having the most diversified usages of rocks used as drugs, since all the types are found there. Although the white color can be seen in both usages (in food preparations and as drugs), they are definitely different when having them in-hand, since the one used in food preparation is friable whereas it is not the case for the one which is used as drug.

Table 1: Rocks used as Traditional Alkaline Salts (TAS)

TAS	Local name	Place of occurrence	Functionality
Food preparation ingredients			
	*Kilbu*, *Kanwa*, *Sel Gemme*, *Potash* and *Limestone*	Sudano-sahelian, High guinea savannah and humid forest	• Reduce the cooking time; • Taste, texture and color improver • Emulsifier; • Preservative • Peels remover
		Humid forest, High guinea savannah and Western highlands	
Drugs			
	*Kanwa Rouge*	Sudano-sahelian, Humid forest and Western highlands	Used against belly pain in both adult and babies
	*Kilbu Latidjam*	Sudano-sahelian	Used against menorrhea pains
	*Mandakiki*		Used against sore throat
	*Kedjamba*		Not reported
	*Kanwa Jaune*	Humid forest and Western highlands	Used against Tinea
Food preparation ingredient and drug			
	*Mandamangoun*	Sudano-sahelian	• Directly consumed or in water extract form against stomach problems. • Replaces NaCl in food preparations for hypertensives.

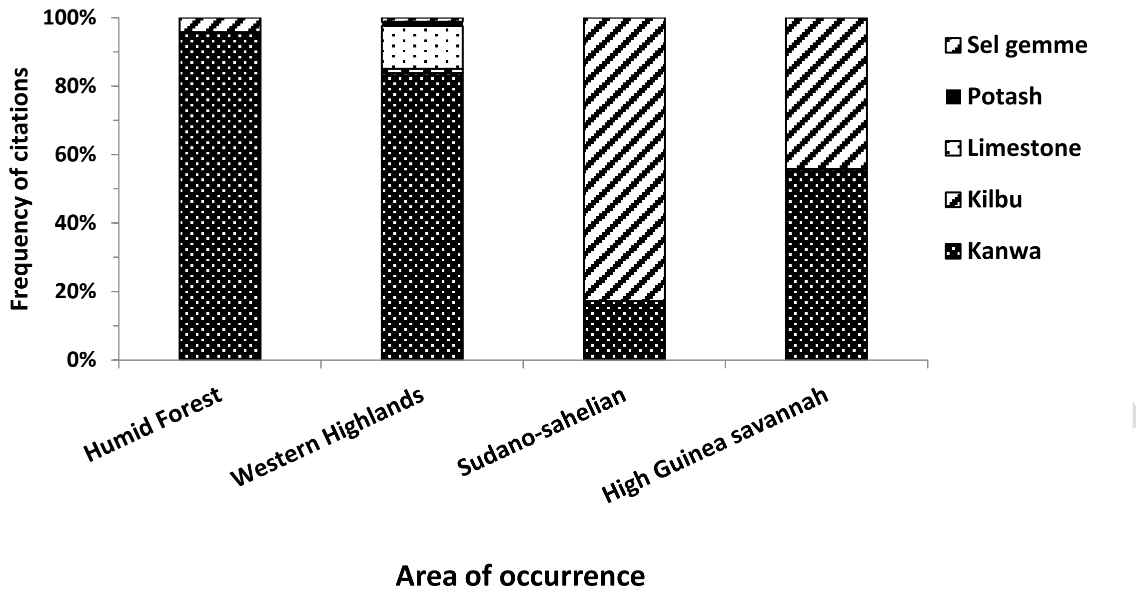


Figure 2: Denominations of rocks generally used in food preparations as TAS according to area of occurrence

3.1.2. Plant-based salts used as Traditional Alkaline Salts

Contrary to rocks, plant-based salts seem to be used only in food preparations, the majority of women using these plant-based TAS (77%), being also users of rocks in food preparations. Their processing diagram, as described by interviewed women (Figure 3), is similar to what has been described by different authors in Africa, South America, India and Papua New Guinea [12,13,17,19,21,24–26,31].

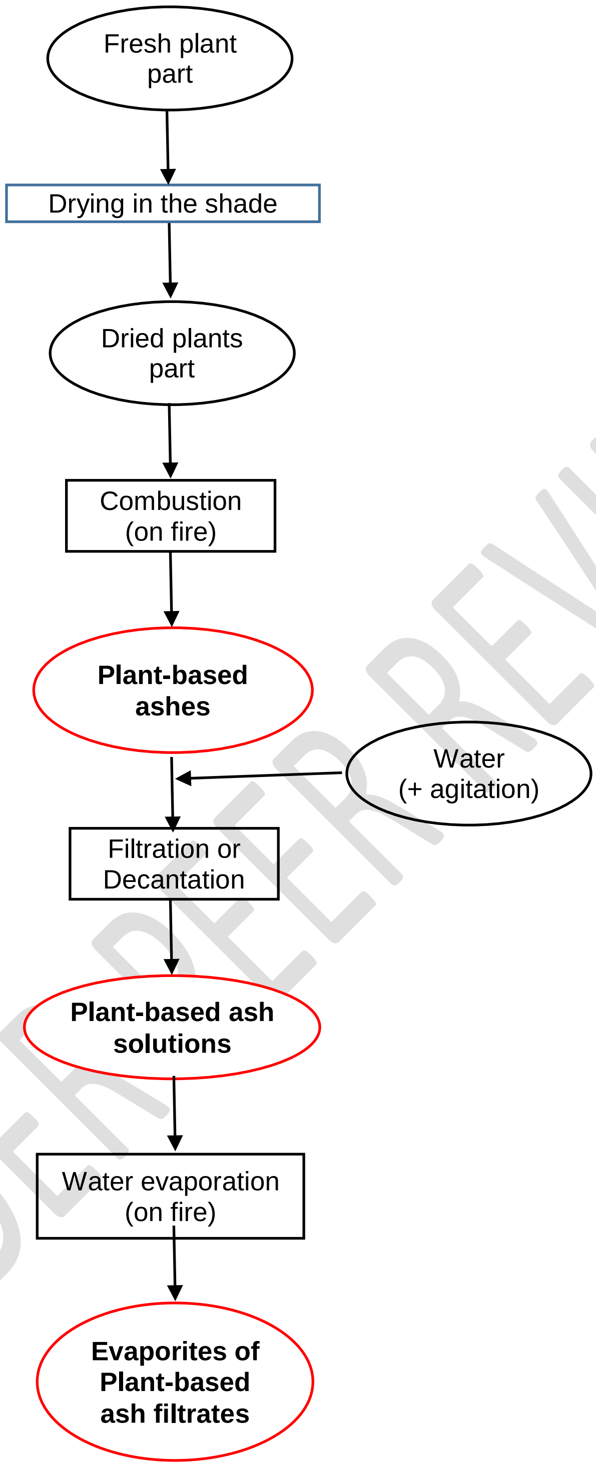


Figure 3: Processing diagram of plant-based salts

Plant-based ashes and their filtrates/solutions, known in majority as *Nikih* seem to be mainly known and used in Western Highlands, while Evaporites of Plant-based ash filtrates, of which common denomination is *Dalang*, is known and used (table 2) in Sudano-sahelian and High Guinea Savannah agro-ecological zones. These denominations have been reported for plant-based ash filtrates (*Nikih*) [41] and its evaporites (*Dalang*) [23] in the same country.

Table 2: Plant-based salts used as TAS

Nature		Main areas of occurrence	Local name*
Plant-based ashes		Western highlands	*Nikih* (73.9%), *Firewood* (4.4%), *Cendres* (literally means ashes in French) (21.7%)
Plant-based ash filtrates	Not found on markets		*Nikih* (15.07%), *Tcheng* (6.84%), *Kié* (1.37%), *Léki* (2.74%), *Lékié* (13.7%), *Liquid Kanwa* (1.37%), *Sel gemme* (12.33%), *Sel gemme indigène* (1.37%), *Sel gemme Traditionnel* (9.59%), *Vinaigre* (6.84%), *Vinaigre indigène* (15.07%), *Vinaigre traditionnel* (8.21%), *Kanwa indigène* (2.73%), *Kanwa traditionnel* (2.73%)
Evaporites of plant-based ash filtrates		Sudano-sahelian and High Guinea savannah	*Dalang* (100%)

*: The percentage in the parenthesis represents the frequency of citations corresponding to each local name.

Plant-based ashes and evaporites of their filtrates are commonly found on market stalls in their place of occurrence, since they exist in a compact and/or powdered solid form with variable colors, and can be stored as such. Though in Sudano-Sahelian areas, where environment is dry, plant-based salts are sold in bulk, they are sealed in plastic bag or paper in Humid Forest markets, in order to avoid humidification, since these TAS are hygroscopic. Plant-based ash filtrates, on the contrary, are rarely found on markets; they are prepared at home for household usages. Their color varies from colorless to brown and reddish.
Plant-based ashes exist in three colors: “Green”, “White” and “Black”, whereas evaporites of their filtrates exist in two colors: “White” and “Black” (table 2). In general, the color of plant-based TAS seems to be related to the nature of plants used for their preparation [24]. In fact, interviewed women consider that white cereals (white maize and white sorghum or millet) generate whitish plant-based ashes and evaporites of their filtrates, whereas cottons stalks and brown cereal (red sorghum and millet) generate black plant-based ashes and evaporites of their filtrates. In the same vein, banana/plantain (*Musa* spp.) stems generate ash with green color. Processing factors constitute another color determinant of plant-based TAS. In this respect, the number of cycles and duration of filtration seem to determine the color (white or black) of evaporites of plant-based ash filtrates. In addition, the degree of compaction of banana/plantain peels and stalks during combustion determine the color of the salts: green with low compaction, black or white with high compaction.
From these findings, checking about the stability of plant-based ash solutions and about the influence of plant types and processing factors on TAS characteristics, appears as research questionable issues.
The above research questions are supported by the diversity of plants available from which plant-based TAS can be processed. It appears that households use mainly local plants available in their areas. In this respect, cereals and beans are the main plants used in Sudano-Sahelian and High Guinea Savannah areas, while banana and plantain peels and stems constitute the major raw material used in Humid Forest and Western highlands (Figure 4).

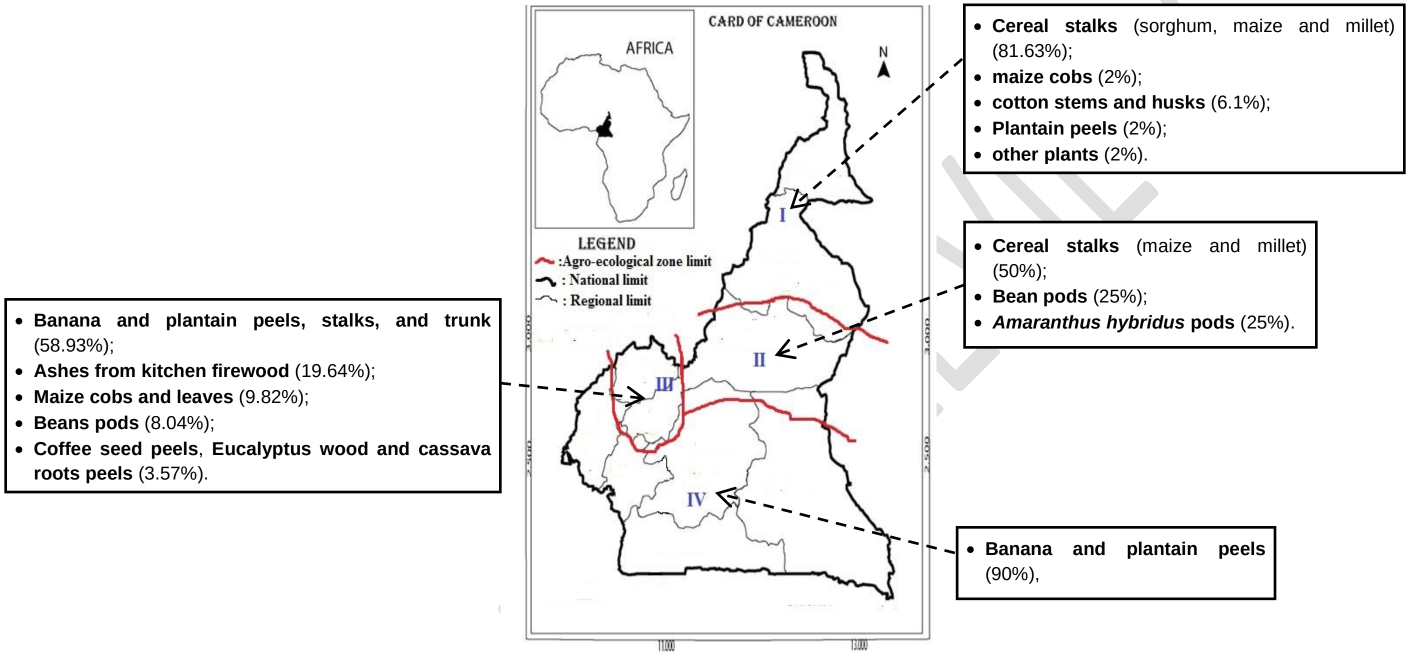


Figure 4: Plants' parts used in the traditional manufacture of TAS in the different agro-ecological zones

3.2. Usages and functionalities of Traditional Alkaline Salts in food preparations

Three main functionalities emerge of TAS usages in food preparations (Fig. 5): *i)* technological auxiliaries, particularly to improve or modify food textures, and as emulsifiers; *ii)* organoleptic additives, to improve the taste and/or the color; *iii)* preservative, to improve the shelf-life of food preparations.

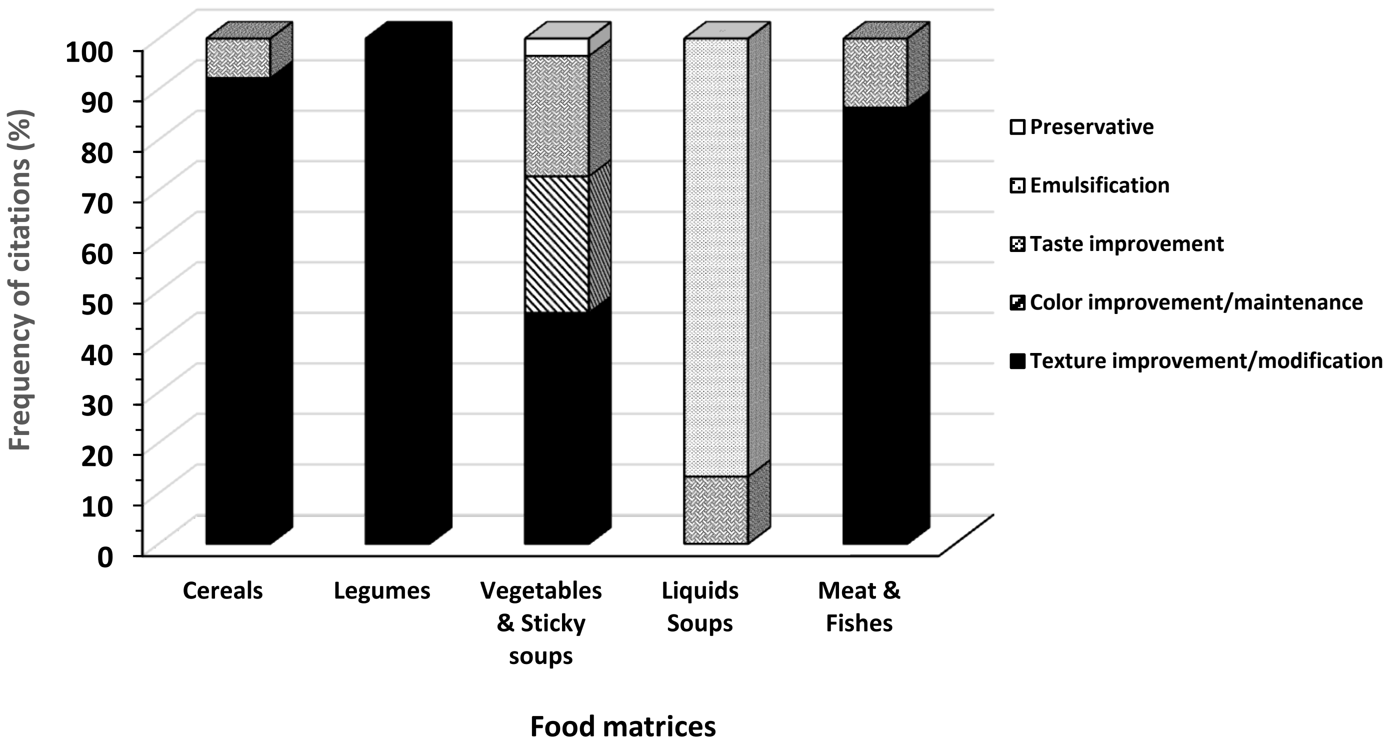


Figure 5: Functionalities of TAS according to food matrices

The texture effect of TAS is related to their ability to weaken cell walls, resulting in the easiness of removing of cereals peels, softening and reduction of cooking time of cereals, legumes, vegetables, meats and fishes. These effects are obtained at household level by adding a portion of TAS in the cooking medium of foods. This is mainly in relation with the alkalinity of TAS as reported by different authors [15,22,31].

Another texture effect of TAS is their aptitude to improve the viscosity of sticky gums extracted from some vegetables (water extract of *Triumfetta cordifolia* stems, fruits of *Hibiscus esculentus* or leaves of *Adansonia digitata*) and used as soups. The mechanism involved in this functionality is the ionic interaction between mineral components of TAS and charged polysaccharides of gums [51–53], probably in combination with the alkaline character of the TAS.

As technological auxiliaries, TAS display an emulsification aptitude used by households to stabilize liquid soup made from a mixture of palm oil and water, locally called "*Achu Soup"* or "*Sauce Jaune*". Though the practice has been reported by some authors [20,30,40,41], the mechanism involved is not clarified.

From organoleptic point of view, TAS allow maintaining or improving the color of vegetables, and even change the color of some vegetable soup (soup from leaves of *Cassia tora* in the preparation of "*Tasba*") from green to yellow. This organoleptic effect is obtained through blanching or cooking of vegetables in the presence of TAS. This treatment allows obtaining vegetable soups with bright green color. In addition, color of dry vegetables cooked in the presence of TAS appears brighter. TAS also improve the taste of food preparations in which they are used, among which the elimination of bitterness (leaves of *Vernonia* spp), acidity (leaves of *Hibiscus sabdariffa* or soup made from *Solanum lycopersicum* L.), and mouth

itching (leaves of *Manihot esculenta* Crantz). Some of these organoleptic properties (effect on taste and color as well as elimination of bitterness) have been reported in literature [12,15,38,39].
Household users also estimate that TAS act as food preservative. This functionality, as expressed by women, allows keeping a soup longer after preparation, without need to reheat it before consumption. The mechanism involved in this assertion constitutes another questionable issue.
Out of the above functionalities, considered as technological functionalities of TAS, based on the fact that effects are observed directly on food matrix, TAS also have biological functionalities related to their metabolic or therapeutic effects. In this respect, foods in which TAS are used (vegetables, legumes, porridge) can be considered as vehicle of TAS functionalities. Thus, based on reports from interviewed women, TAS allow normalizing digestive disorders through avoidance of stomach distending and stomach cleaning of breastfeeding women. These effects have been reported in India with specific use of plant-based ashes [19]. This apparent specificity seems to confirm the assertion of interviewed women, who consider that, contrary to plant-based TAS, Lakes' deposits have negative effects concerning mainly: gastric ulcer irritation and aggravation of hypertension. However, women report, in the case of *Achu Soup*/*Sauce Jaune*, that irritation of gastric ulcer isn't observed when Lakes' deposits are burnt before their uses.
Based on women's responses, the achievement and efficiency of the above functionalities seem to be related to the type and concentration of TAS used. In this respect, the range of concentrations used for each type of TAS and food matrix is highly variable (table 3).

Table 3: Concentration ranges (% of food matrix) of Traditional Alkaline Salts used in food preparations

Food preparation	**Lakes' deposits**	**Plant-based ashes**	**Evaporites of Plant-based ash filtrates**	**Plant-based ash filtrates**
Cereals	0.2 - 6	0.15 - 1.51	NR	0.3 - 37.9
Legumes	0.02 - 3	0.1 - 0.4	NR	0.07 - 9.4
Vegetables & sticky soups	0.04 - 10.6	NR	0.05 - 15.8	0.1 - 3.41
Liquid soups	0.2 - 5	0.3 - 3	NR	0.7 - 10
Meat & Fishes	0.6 - 1.2	NR	0.6 - 1.34	NR

NR: Not reported.

In general, women link the variability of concentration ranges used, both to types of TAS and foods, depending on the sought functionality. This may explain why, according to women, evaporites of plant-based ash filtrates are used only on leaves of *Moringa oleifera*, *Balinites aegyptica* ,*Vigna unguiculata, Cassia tora*, *Cerathotheca sesamoïdes* ,and *Adansonia digitata,* while Lakes' deposits are used only on porridge, leaves of *Manihot esculanta* Crantz, *Allium cepa*, and *Hibiscus cannabicus*. Meanwhile, women indicate that high concentration of TAS may lead to diarrhea, depreciation of texture and color (legumes and vegetables), and decrease of the stickiness of soups. This rises up the need of some skills when using TAS to obtain right sought functionality.
With respect to the highly variable ranges of TAS used in food, coupled with the negative effects observed above, questions may arise on the toxicity and health risks associated to the level of use of TAS. This questioning is supported by medical informations reported in Nigeria on Peripartum cardiac failure prevalence associated to high consumption of TAS by breastfeeding women [54]. Moreover, different studies have shown that consumption of TAS at dose equal or greater than 100 mg/Kg of weight, results in disturbance of the physiology of kidney, liver and intestine. [7,14,46,55].

4-CONCLUSION

Traditional Alkaline Salts used in food preparation present a high variability represented by their nature (rocks of plants), their denomination and their functionalities. Rocks, mainly Lakes' deposits, and plant-based salts constitute the two main forms of Traditional Alkaline Salts (TAS) used in food preparations in Africa. They are commonly named "*Kanwa*" and "*Kilbu*" for Lakes' deposits, or "*Nikih*" and "*Dalang*" for plant-based salts, depending on region of occurrence. The diverse features and uses, and particularly their functionalities, mainly oriented by the know-how of their users, rise up research questions related to their chemical composition and mechanisms involved in their physicochemical properties. Moreover, though the beneficial health effects of TAS are admitted by users, the level and manner of uses, coupled to their history (origin of rocks for lakes' deposits; nature and pre-treatments of plant-based TAS) constitute another interesting research issue for TAS, in terms of related toxicity risks.

COMPETING INTERESTS

Authors declare that no competing interests exist.

REFERENCES

1. ARS. CD-ARS 471 (2014) (English): Food grade salt — Specification. 2014. Accessed: 29 April 2017. Available: www.arso-oran.org/wp.../CD-ARS-471-2014-Food-grade-salt-—-Specification.pdf

2. Codex Alimentarius. CODEX STAN 150-1985, CODEX standard for food grade salt. 2006. Accessed: 21 February 2017. Available: http://www.fao.org/fao-who-codexalimentarius/sh-proxy/ar/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCODEX%2BSTAN%2B150-1985%252FCXS_150e.pdf

3. Codex Alimentarius. General standard for food additives CODEX-STAN 192-1995. 2016. Accessed: 21 February 2017. Available: http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCODEX%2BSTAN%2B192-1995%252FCXS_192e.pdf

4. Teissier T, Colin C. Le sel dans les industries alimentaires. 2004. Accessed: 21 February 2017. Available: http://julientap.free.fr/travail_fichiers/le_sel.pdf. French

5. Ankrah EK, Dovlo FE. The properties of Trona and its effects on cooking time of cowpeas. J Sci Food Agric. 1978;29:950–2.

6. Edijala JK. Effects of processing on the thiamin, riboflavin and protein contents of cowpeas (Vigna unguiculata (L) Walp) II. Alkali ("potash") treatment. J Food Technol. 1980;15:445–53.

7. Imafidon KE, Egberanmwen ID, Omoregie IP. Toxicological and biochemical investigations in rats administered "kaun" (trona) a natural food additive used in Nigeria. J Nutr Intermed Metab. 2016;6:22–5.

8. Nnorom IC, Ebo O, Nduka K, Igwe JC, Nwoko C. Metal contents of Akanwu(Trona): Estimation of Target Hazard Quotients (THQ) and Dietary Intake Benefits and Risks. ABSU J Environ Sci Technol. 2012;2:275–89.

9. Osano AM, Okong'o ER, Oyaro N, Kiptoo J. Compositional and Structural Characterization of Three Basic Indigenous Salts Used in Kenya: A Case Study of "Ebara", "Magadi" and "Lebek" Crystalline Salts. Int J Adv Res Technol. 2013;2:118–23.

10. Saidou H, Hamzaoui AH, Mnif A. Insoluble Content, Ionic Composition, Density, and X-Ray Diffraction Spectra of 6 Evaporites from Niger Republic. J Appl Chem. 2015;2015:10 pages.

11. Uzogara SG, Morton ID, Daniel JW. Quality Changes and Mineral Content of Cowpea (Vigna unguiculata L. Walp) Seeds Processed with "Kanwa" Alkaline Salt. Food Chem. 1988;30:1–18.

12. Bergeson TL, Opio C, MacMillan PD. Crop ash filtrate influence on cooking time and sensory preferences for dried black beans (Phaseolus vulgaris L.). Afr J Food Sci. 2016;10:132–42.

13. Croft JR, Leach DN. New Guinea salt fern (Asplenium acrobryum Complex): identity, distribution, and chemical composition of its salt. Econ Bot. 1985;39:139–49.

14. Okoye JO, Oranefo NO, Okoli AN. Comparative evaluation of the effects of palm bunch ash and trona on the liver of Albino rats. Afr J Cell Pathol. 2016;6:21–7.

15. Onwuka UN, Okala O. Effects of selected salts on the cooking time, protein content and sensory properties of African yam beans and cowpeas. Food Serv Technol. 2003;3:3–7.

16. Schemeda-Hirschmann G. Tree ash as an Ayoreo salt source in Paraguayan Chaco. Econ Bot. 1994;48:159–62.

17. Townsend PK, Liao SC, Konlande JE. Nutritive contribution of Sago ash used as a native salt in Papua New Guinea. Ecol Food Nutr. 1973;2:91–7.

18. Avallone S, Tiemtore T-WE, Mouquet-Rivier C. Nutritional value of six multi-ingredient sauces from Burkina Faso. J Food Compos Anal. 2008;21:553–8.

19. Deka DC, Talukdar NN. Chemical and spectroscopic investigation of Kolakhar and its commercial importance. Indian J Tradit Knowl. 2007;6:72–8.

20. Ene-Obong HN, Sanusi RA, Udenta EA, Williams IO, Anigo KM, Chibuzo EC, et al. Data collection and assessment of commonly consumed foods and recipes in six geo-political zones in Nigeria: Important for the development of a National Food Composition Database and Dietary Assessment. Food Chem. 2013;140:539–46.

21. Mianpeurem T, Mbailao M, Nambatingar N. Elemental composition of vegetable salts from ashes of four common plants species from Chad. Int J Pharmacol. 2012;8:582–5.

22. Wanjekeche E, Wakasa V, Mureithi JG. Effect of germination, alkaline and acid soaking and boiling on the nutritional value of mature and immature Mucuna(Mucuna pruriens) beans. Trop Subtrop Agrosystems. 2003;1:183–92.

23. Doumta CF, Tchiégang C. Standardisation process to soften African Locust Beans Seeds (Parkia biglobosa Benth) by a traditional method. Food Glob Sci Books. 2012;6:33–7.

24. Echeverri JA, Román-Jitdutjaaño O "Enokakuiodo." Witoto ash salts from the Amazon. J Ethnopharmacol. 2011;138:492–502.

25. Echeverri JA, Román-Jitdutjaaño O "Enokakuiodo." Ash salts and bodily affects: Witoto environmental knowledge as sexual education. Environ Res Lett. 2013;8:13 pages.

26. Lemonnier P. La production de sel végétal chez les Anga (Papouasie Nouvelle-Guinée). J Agric Tradit Bot Appliquée. 1984;31:71–126. French

27. Nkama I, Malleshi NG. Production and nutritional quality of traditional Nigerian masa from mixtures of rice, pearl millet, cowpea, and groundnut. Food Nutr Bull. 1998;19:366–73.

28. Sodipo AO. How safe is the consumption of Trona? Am J Public Health. 1993 Aug;83:1181.

29. Venkatesh KVL, Shurpalekar SR, Prabhakar JV, Amla LB. Physico-chemical characteristics of papad (sajji) khar. J Food Sci Technol. 1970;7:106–9.

30. Ekosse G-IE. X-ray diffraction study of kanwa used as active ingredient in Achu soup in Cameroon. Afr J Biotechnol. 2010;9:7928–9.

31. Mamiro P, Nyagaya M, Kimani P, Mamiro D, Jumbe T, Macha J, et al. Similarities in functional attributes and nutritional effects of magadi soda and bean debris-ash used in cooking African traditional dishes. Afr J Biotechnol. 2011;10:1181–5.

32. Navaratne SB. Determination of changes occurrence in physical, chemical and organoleptic properties of papadam during storage. Int J Sci Eng Res. 2014;5:1641–8.

33. Senthil A, Ravi R, Kumar AKV. Quality characteristics of blackgram papad. Int J Food Sci Nutr. 2006;57:29–37.

34. Srinivasan P, Annapure US, Sahoo AK, Singhal RS, Kulkarni PR. Mini-papad containing cheese powder—a novelty snack food. Int J Food Sci Nutr. 2000;51:175–80.

35. Tite MS, Shortland A, Maniatis Y, Kavoussanaki D, Harris S. A. The composition of the soda-rich and mixed alkali plant ashes used in the production of glass. J Archaeol Sci. 2006;33:1284–92.

36. Kaputo MT. The roles of ashes and sodium bicarbonate in a simulated meat product from Chikanda tuber (Satyria siva). Food Chem. 1996;55:115–9.

37. Muindi PJ, Thomke S, Ekman R. Effect of Magadi Soda treatment on the tannin content and in-vitro nutritive value of grain Sorghums. J Sci Food Agric. 1981;32:25–34.

38. Ejoh RA, Nkonga DV, Gouado I, Mbofung CM. Effect of the method of processing and preservation on some quality parameters of three non-conventional leafy vegetables. Pak J Nutr. 2007;6:128–33.

39. Latunde-Dada GO. Effect of processing on iron levels in and availability from some Nigerian vegetables. J Sci Food Agric. 1990;53:355–61.

40. Tchiégang C, Mbougueng PD. Composition chimique des épices utilisées dans la préparation du Nah pohet du Nkui de l'ouest Cameroun. TROPICULTURA. 2005;23:193–200.

41. Mbawala A, Fopa Kue RE, Mouafo Tene H. Evaluation of the emulsifying activity and stability effect of biosurfactants, Kanwa, and Nikih in Yellow Achu Soup. J Chem Biol Phys Sci JCBPS. 2015;5:3851.

42. Minka SR, Mbofung CMF, Gandon C, Bruneteau M. The effect of cooking with kanwa alkaline salt on the chemical composition of black beans (Phaseolus vulgaris). Food Chem. 1999;64:145–8.

43. Shaikh MB, Tarade KM, Bharadwaj VR, Annapure US, Singhal RS. Effect of an alkaline salt (papad khar) and its substitute (2:1 sodium carbonate:sodium bicarbonate) on acrylamide formation in papads. Food Chem. 2008;113:1165–8.

44. Uzogara SG, Morton ID, Daniel JW. Thiamin, riboflavin and niacin retention in cooked cowpeas as affected by kanwa treatment. J Food Sci. 1991;56:592–3.

45. Uzogara SG, Morton ID, Daniel JW. Processing, microstructural and nutritional changes in cowpeas (Vigna unguiculata) cooked in Kanwa alkaline salt. Proc Workshop Tradit Afr Foods Qual Nutr. Dar-es-Salam, Tanzania: International Foundation for Science; 1992. p. 99–107.

46. Ajiboye TO, Komolafe YO, Yakubu MT, Ogunbode SM. Effects of trona on the redox status of cellular system of male rats. Toxicol Ind Health. 2015;31:179–87.

47. Bamaiyi OJ, Momoh S. Effects of kanwa on rat gastrointestinal phosphatases. Int J Pharm Sci Nanotechnol. 2010;3:1147–52.

48. Ngom E, Ndjogui E, Nkongho Ndip R, Iyabano A, Levang P, Miaro III L, *et al*. Diagnostic du secteur élæicole au Cameroun: Appui technique au groupe de travail sur La stratégie de développement durable de la filière palmier à huile au Cameroun. CIRAD/IRD/CIFOR; 2014. Accessed: 6 December 2018. Available: http://agritrop.cirad.fr/578773/. French

49. Oladele AK, Ibanga UI, Aina JO. Starch modification potential of Kanwa, an alkaline salt. J Appl Biosci. 2008;7:191–4.

50. Alawa NJ, Kwanashie OH, Singh SP, Alawa BIC. Effect of natron(Kanwa) varieties on murine virgin uterine contractility [Internet]. 2012 [cited 2019 Jan 8]. Available from: https://studyres.com/doc/2115982/on-murine-uterine-contractility.---0-vol.-22--no.-1---201...

51. Dário AF, Hortêncio LMA, Sierakowski MR, Neto JCQ, Petri DFS. The effect of calcium salts on the viscosity and adsorption behavior of xanthan. Carbohydr Polym. 2011;84:669–76.

52. Marin J, Zee JA, Kouaouci R. Effect of hydrocolloids on potential availability of calcium. Le lait. INRA Edition. 1990. p. 467–73.

53. Zhang S, Zhang Z, Vardhanabhuti B. Effect of charge density of polysaccharides on self-assembled intragastric gelation of whey protein/ polysaccharide under simulated gastric conditions. Food Funct. 2014;5:1825–38.

54. Muhammad AS, Saidu Y, Bilbis LS, Onu A, Isezuo SA, Sahabi S. Effect of dried lake salt(kanwa) on lipid profile and heart histology of female albino rats. Niger J Basic Appl Sci. 2014;22:73–8.

55. Bamaiyi OJ, Momoh S. Effect of Kanwa on rat gastrointestinal phosphatases. Int J Pharm Sci Nanotechnol. 2010;3:1147–52.